EM477 Computer-Aided Design, Fall 1998
Finite Element Analysis Design Project

Introduction: A top secret program is underway to develop the next generation fighter aircraft. Weight reduction of all structural components is a key issue in this design. Every ounce of material should be used to its fullest extent to maximize the payload carrying capacity of the aircraft. The designers have spared no expense in achieving this goal. They have even developed a new material, transparent aluminum, for special structural applications. One component made out of this material is the Auxiliary Attachment Bracket shown in Figure 1. This bracket connects a payload to the underside of one of the wings of the aircraft. It is attached to the wing by two 0.375 in. dia. steel pins spaced 7 inches apart as shown. The payload is attached by another 0.375 in. dia. steel pin. When the bracket is mounted in position, it restricts access to an inspection cover located on the fuselage just behind the bracket. The aircraft mechanics must be able to access this cover even when the bracket is in place, so a hole was cut into the bracket to permit access. Early prototypes have been experiencing repeated failures of the bracket because of the high stress concentration at the sharp corners of the opening. You have been tasked to redesign this bracket to optimize its strength-to-weight ratio. The bracket must be able to support a force, F, of 500 lbs directed as shown. The deformation of the bracket must be limited so that the pin at C does not displace more than δ=0.200 in. when the load is applied or the payload will come into contact with other critical components.
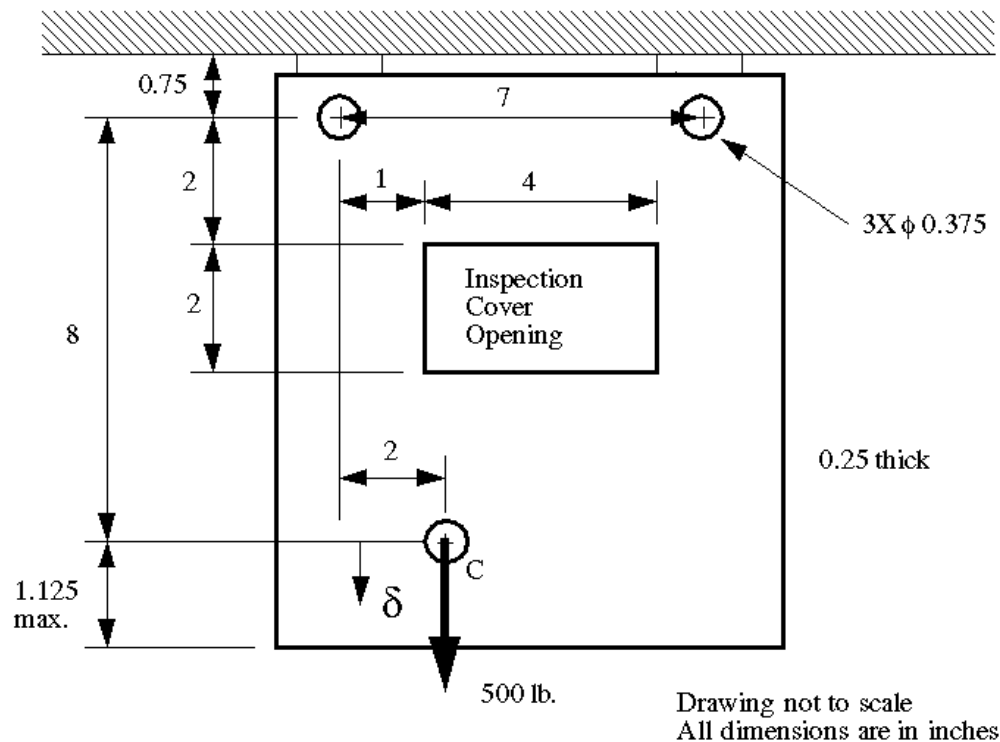

Figure 1 General dimensions for Auxiliary Attachment Bracket. (Note that this sketch is not to scale.)

Objective: Optimize the design of an Auxiliary Attachment Bracket used to support a payload. Modify the design to achieve the best strength to weight ratio for the bracket while limiting the deformation of the load point to acceptable values.

Assignment: Each midshipman will attempt a design of the bracket individually. Finite element analysis should be used to determine the stresses and deformation of the bracket under the design load. Teams of four midshipmen will be formed and the team members will compare their individual designs to select the best one. As a team, this design will be refined to optimize the performance (highest strength-to-weight ration within allowable deformation limits). Each team will fabricate a model of their bracket from ¼ inch thick polycarbonate sheet. Each team will be issued one 12 in. x 12 in. piece of material. (This is large enough to make two brackets in case one gets screwed up.) The brackets will be fabricated using the tools available in Rickover 15 (band saw, scroll saw, drill press, sander, hand tools).

Proof Testing: On Wednesday, 2 DEC 98, and Thursday, 3 DEC 98, the brackets will be proof tested to see if they meet the deflection requirements and then loaded until failure to determine the ultimate strength-to-weight ratio. Each team shall provide an estimate of the ultimate strength of their bracket and a prediction of where the bracket will fail.

Final Report: Each team will submit a final report that describes each of the team members individual designs and the optimization of the final design. Each design should be analyzed to identify the good and bad points of the design (too high a stress, too compliant, too heavy, etc.) The criteria used to judge the designs should be clearly stated. Explain the failure theory (or theories) used to predict the performance of your bracket and why this theory was selected. Be sure to include detailed drawings of each of the designs and any figures and tables necessary to support your analysis. Make sure that your narrative refers to the figures. The final report is due 11 Dec. 1998.

Material Properties: The mechanical properties of the transparent aluminum are listed in the following table.

Property	Transparent Aluminum (HYZOD™GP)
Yield Strength (psi)	9,000
Ultimate Strength (psi)	9,500
Modulus of Elasticity (psi)	345,000
Weight Density (lb/in^3)	0.045

Grading: The grade will be based on both the actual performance of your bracket and on your final report. The report will count for 80%, meeting the deflection requirement at 500 lb of load will be worth 10% and 10% of the grade will be based on the strength-to-weight ratio of the bracket compared to the other competing designs.